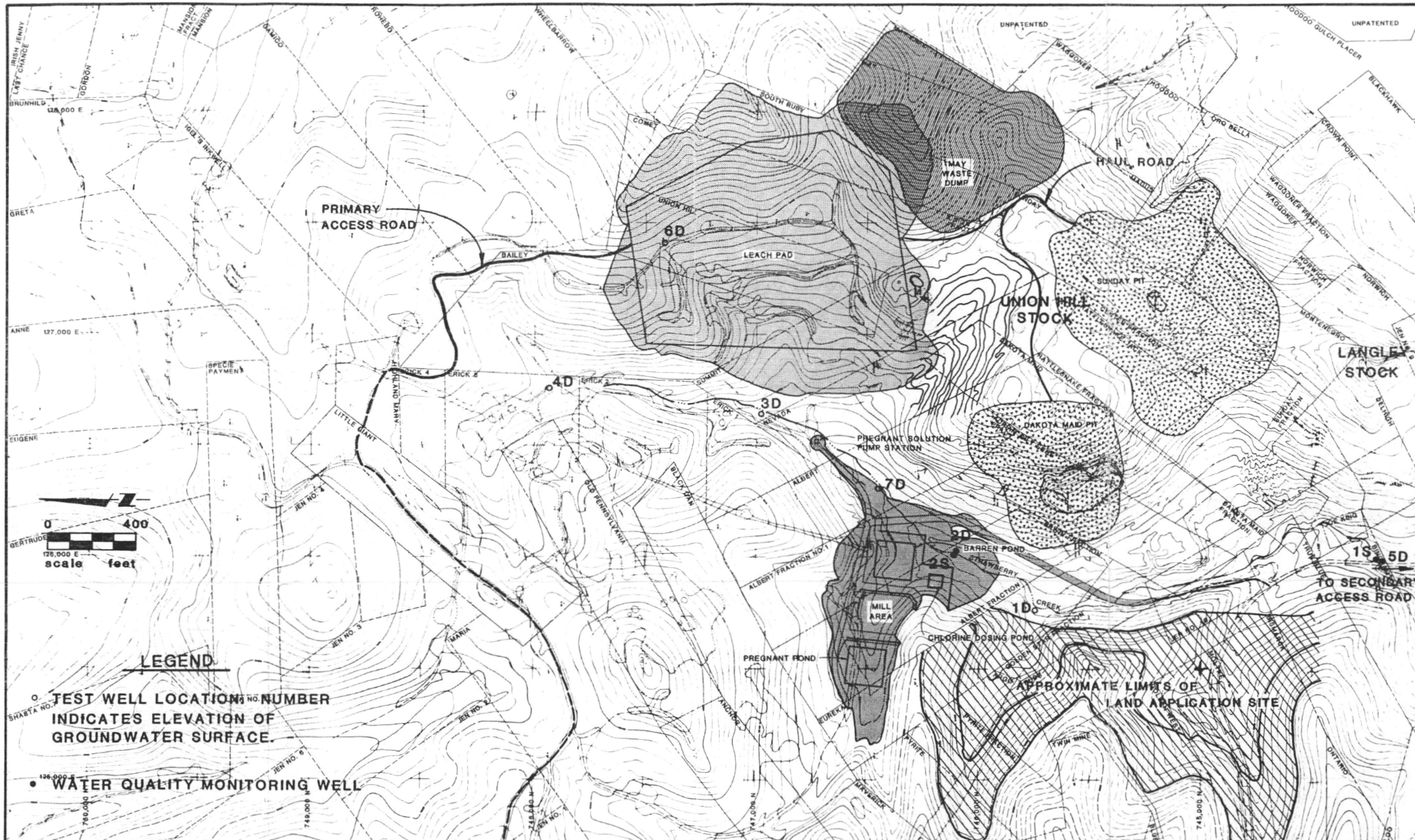


FIGURE 3

TEST WELL LOCATIONS
AND PRELIMINARY LAYOUT
OF MINING OPERATION

N

0 2000 4000
scale feet
CONTOUR INTERVAL - 80 FEET

LEGEND

----- DIRT ROAD
MINE SITE
-·-·- EXISTING MINE TAILINGS

GILT EDGE MINE PROJECT

DISTURBED AREAS
FIGURE 4

Subbasins 2 and 3 (Figure 2) are not associated with the Strawberry Creek drainage but are delineated due to limited fill slope of the leach pad and waste dump extending over the ridge top into each subbasin, respectively.

Topography. The general topography of the Gilt Edge mine project study area is characterized by mountainous terrain with narrow valleys. The higher surrounding mountain elevations range from 5,600 to 5,680 feet. The elevation of the main valley ranges from 5,322 to 5,480 feet above sea level. Faulting and uplifting and fluvial action has contributed to the shaping of local topography. The highest point on the north side of the study area is Anchor Hill at an elevation of 5,680 feet. The east side of the study area has an unnamed peak at approximately 5,650 feet in elevation. The lowest point in the study area is 5,322 feet at Design Point One (subbasin 1).

The mountainous portion of the study area has slopes ranging from 6 to 60 percent. Slopes steeper than 60 percent are not common in the vicinity of the project area.

Butte ? **Soils Characteristics.** The existing soils inventory and classification of the Bear Valley Creek study area was conducted by the Soil Conservation Service in 1979. Generally, the soils in the area are young in terms of their geologic age. Soil types in the study area are comprised of three main associations (Figure 3).

The predominant soil in the study area is the Grizzly-Virkula association. This soil type has deep well drained soils on ridges and sides of mountain valleys. The typical slopes are 25 to 60 percent. The predominant soil texture is very gravelly silt loam to gravelly silt loam. Available water capacity of this association is high, with a rapid runoff potential.

The Virkula association is the other predominant soil type found in the study area (Figure 3). This soil type is comprized of deep well drained soils with slopes ranging from 6 to 30 percent. The typical soil texture of the Virkula association is a very friable silt loam to a friable silty clay loam. The available water capacity is moderate to high with a medium to rapid runoff characteristic.

The permeability of both the Grizzly-Virkula and Virkula associations is moderate. Permeability rates average about 4 inches per hour for both of the major soil associations found in the study area.

The last soil type found in the study area is a mine dump soil consisting of mine tailing. The typical texture of the tailings is very fine with the larger fragments being up to one quarter inch in diameter. Usually the mine dumps are barren of vegetation.

Infiltration Characteristics. The Soil Conservation Service's Soil Survey of Lawrence County, South Dakota (1979) indicates that a permeability of 2.0 to 6.0 in/hr is typical for the study area. The infiltration characteristics may be considered in terms of initial loss, measured in inches, and a uniform loss rate, with units of inches per hour. The initial loss is that amount of precipitation which enters the soil surface from the beginning of a storm event until the soil is saturated. When the initial loss is satisfied, the precipitation then infiltrates at a uniform loss rate throughout the duration of the storm event. Runoff occurs when the amount of precipitation is greater than the initial loss and the rainfall intensity exceeds the uniform loss rate.

The initial loss and uniform loss rates were estimated for soils within the Gilt Edge mine project study area using the SCS classification system for determining the hydrologic soil group and hydrologic soil-cover complex curve number. The soils found in the study area were analyzed to determine the hydrologic soil group designation; provided by the SCS in the Soil Survey of Lawrence County, South Dakota. JMM reviewed all available soils data along with vegetative characteristics and geographic characteristics of the study are to determine appropriate hydrologic soil-cover complex curve numbers for the subbasins. The overall hydrologic soil group "B" best represents the soils of the Gilt Edge area. Group B soils have moderate infiltration rates when thoroughly wetted and consist primarily of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures, characterized by a moderate rate of water transmission. The hydrologic soil group classification for the Strawberry Creek study area is summarized in Table 2.

TABLE 2

HYDROLOGIC SOIL GROUP CLASSIFICATION

Map Unit	Soil Description	Runoff Characteristics	Erosion Hazard	Slope	Hydrologic Soil Group
GBE	Grizzly-Virkula Association	Rapid	Moderate to Severe	25-60%	B
VCE	Virkula Association	Moderate to Rapid	Severe	6-30%	B
Cc	Mine Dumps	---	---	---	---

The hydrologic soil-cover complex curve number (CN) was estimated based on vegetation, slope, aspect, runoff/erosion hazards and the hydrologic soil group. The estimated CN values developed for the Strawberry Creek drainage is 57 for all subbasins. Soils with higher CN values generate more runoff than soils with lower CN values during precipitation events. The range of possible CN values is from 0 to 100.

The CN value was selected based on the methodologies and descriptions of land conditions developed by the SCS. The initial loss was estimated from the CN using the following equations:

$$S = 1000/CN - 10 \qquad \text{(equation 1)}$$

$$Ia = 0.2S \qquad \text{(equation 2)}$$

where:
- S = maximum potential difference between the storm rainfall and direct runoff
- CN = hydrologic soil-cover complex curve number
- Ia = initial loss

The initial loss of precipitation to soils of the Strawberry Creek study area is estimated at 1.51 inches. Uniform losses were estimated from data on minimum infiltration rates for different hydrologic soil groups and CN values provided by the Soil Conservation Service.

Influence of Vegetative Cover on Precipitation Runoff. The influence of cover on precipitation runoff is threefold. Precipitation is intercepted by vegetation from direct contact with the soil surface through wetting, absorption and transmission into the ground through the root matricies. In areas where species begin to intermix a closed canopy is usually prevalent which largely prohibits the soil surface of this area from receiving significant precipitation. This is attributed to the canopy effect as well as the smaller growth typically preceeding the formation of the canopy. The increased surface area of the vegetation intercepts the precipitation and disposes of it through absorption, wetting and evaporation, and transmission into the soil.

The amount and types of vegetation can greatly influence the quantity of runoff to be experienced from a watershed. The vegetative cover must be considered when evaluating runoff potential within a drainage basin. Vegetative cover occurring in the study area is characterized by Ponderosa pine which is dominant on the mountainous portion of the study area, and meadow and riparian vegetation found in the valley adjacent to the stream channel where mining has not disturbed the plant communities. The forest overstory density of the study area ranges from 20 to 80 percent. Some Black Hills spruce along with quaking aspen, bur oak, and paper birch growth occurs.

Open Impervious Areas. The impervious areas within the study area drainage basin include rock outcroppings, which are generally found along ridge tops, and to some extent hard surfaced dirt roads. The potential exists for a large portion of precipitation falling on impervious or semi-impervious areas to eventually flow into a stream channel. Prior to reaching the stream channel, runoff from these areas filters through the forest as overland flow or shallow subsurface flow.

Another type of impervious area common within any previously disturbed environment is that created by access roads. The roads located in the study area are associated with mining activities and forest access. Forest access roads have been developed for land management activities such as timber harvesting and for recreational uses. The major existing and past mining activities are located on Figure 4.

Precipitation Features. Actual site specific precipitation data for the Gilt Edge mine project study area are not available. Isohyetal maps showing annual precipitation rates for the State of South Dakota were utilized to extrapolate this information for use in determining summer thunderstorm and general rainstorm events and related planning and preliminary siting studies. These data also provide design criteria for sizing culverts and other facilities, except the leach pad system which is sized based on the 6 year PMP event. ? 6 hour

Climatological Characteristics. The climatological characteristics of the study area have been extrapolated from measurements recorded for a nearby weather station at Lead, South Dakota. The climatological data used includes average air temperature (monthly and annually), average precipitation (monthly and annually), and average snowpack (annually).

Hydrologic Model Input Data and Assumptions

The input parameters for the HEC-1 model may be separated into four distinct groups of data: 1) precipitation characteristics; 2) runoff characteristics; and 3) stream channel characteristics. Portions of the input data were assumed using best engineering judgement where field investigations were not performed or actual climatic data were not available.

Precipitation Characteristics. The precipitation characteristics include the amount of rainfall, and the distribution of that rainfall throughout the storm duration. The input data is in the form of total precipitation for a specified duration, followed by a distribution characteristic of either a PMP event, a thunderstorm event, or a general rainstorm event. The precipitation events selected for the modeling effort are shown in Table 3. The 2, 10, 50, and 100-year storms were selected for modeling because the return frequencies represent a range of precipitation events, and will yield a corresponding range of streamflows for alternative analyses. It is important to note that the thunderstorm event occurs over an area not larger than two to three square miles, and the general rainstorm event occurs over a much larger area.

TABLE 3

PRECIPITATION EVENTS USED
FOR RUNOFF MODELING IN THE
GILT EDGE PROJECT AREA

Return Frequency (Yrs)	Duration (Hrs)	Intensity* (in/hr)	Total Precipitation* (inches)
2	1	0.85	0.85
10	1	1.5	1.5
50	1	2.1	2.1
100	1	2.4	2.4
2	24	0.085	2.04
10	24	0.16	3.84
50	24	0.23	5.52
100	24	0.25	6.0
PMP	6	3.25	19.6

*Intensity and total precipitation data will be obtained from the South Dakota Department of Transporation when available.

Runoff Characteristics. Runoff input data include: 1) the subbasin area; 2) soil water loss information; 3) consideration of impervious areas; and 4) subbasin lag time. The subbasin areas were determined using a 7.5 minute USGS map. The subbasin areas are presented in Table 4.

Soil infiltration losses were estimated using SCS hydrologic soil cover complex numbers determined after completing inspection of the drainage basins. The HEC-1 model input utilizes an initial loss which is satisfied before infiltration occurs at a uniform loss rate. The estimated initial loss and uniform loss rates for each subbasin are shown in Table 4.

The impervious areas within each subbasin were estimated based on field inspection and examination of photographs, and are included in Table 4. Roads were assumed to be 90 percent impervious. The subbasin lag time (L) was also estimated using the hydrologic soil cover complex number, greatest flow length, and the average watershed slope in the following equation:

$$L = \frac{\ell^{0.8}(S+1)^{0.7}}{1900\ Y^{0.5}} \qquad \text{(equation 3)}$$

Where:
- L = lag time in hours
- ℓ = greatest flow length in feet
- S = 1000/CN - 10
- CN = hydrologic soil-cover complex curve number
- Y = average watershed slope in percent

(equation from SCS National Engineering Handbook, Section 4)

The estimated lag time for each subbasin is shown in Table 4.

TABLE 4

RUNOFF CHARACTERISTICS FOR HEC-1 MODELING OF PMP EVENT FOR THE GILT EDGE PROJECT HYDROLOGIC BASINS

Subbasin Number	Subbasin Area (mi^2)	Initial Loss (inches)	Uniform Loss Rate (in/hr)	Impervious Area (Pct. of Basin Area	Subbasin Lag Time (hrs)
1	0.39	1.51	2.0	1	0.43
2	0.05	1.51	2.0	0	0.15
3	0.07	1.51	2.0	0	0.17

NOTE: Antecedent Moisture Condition II Assumed.

Significance of Design Points

The design points for the storm runoff modeling were selected using several criteria. Each design point represents where drainage from the project meets with drainage from the forest. The design points shown in Figure 2 were selected considering the following criteria:

- Location of design point at the location of major drainage areas with the main stream channel.
- Relationship of design point to the drainage from the proposed mining project.

- Design point is representative of adjacent upstream and downstream channel reaches.

- Location of ridges and other terrain features which could affect runoff.

All of the design points in the Gilt Edge study area were selected based on location with respect to the drainage from the subbasins where mining activity is expected to occur.

Results of HEC-1 Modeling

The results of modeling various precipitation/runoff events for the Gilt Edge mine project hydrologic basins are in the form of quantitative flood hydrographs with peak flows. A hydrograph is a graph of discharge versus time, and an example hydrograph of runoff streamflow is shown in Figure 5. The runoff hydrograph consists of a rising limb, crest segment, and recession curve. The rising limb reflects the increase in streamflow during a runoff event. The crest segment of the hydrograph characterizes the period during which streamflow is greatest, and ends at an inflection point on the falling side of the hydrograph. The recession curve represents the withdrawal of water from storage within the drainage basin. The estimated base flow is the contribution from groundwater. The runoff volume may be calculated by integrating the area under the curve of the hydrograph. The peak flow occurs during the crest segment and is the maximum discharge of the runoff event.

The peak flows at the basin outlet for the PMP runoff event are shown in Table 5. The peak flows from the thunderstorm events and the general storm events utilized to size individual culverts and drainage facilities other than the pad and plant site drainage systems will be provided at such time as initial approvals are secured and final design is completed.

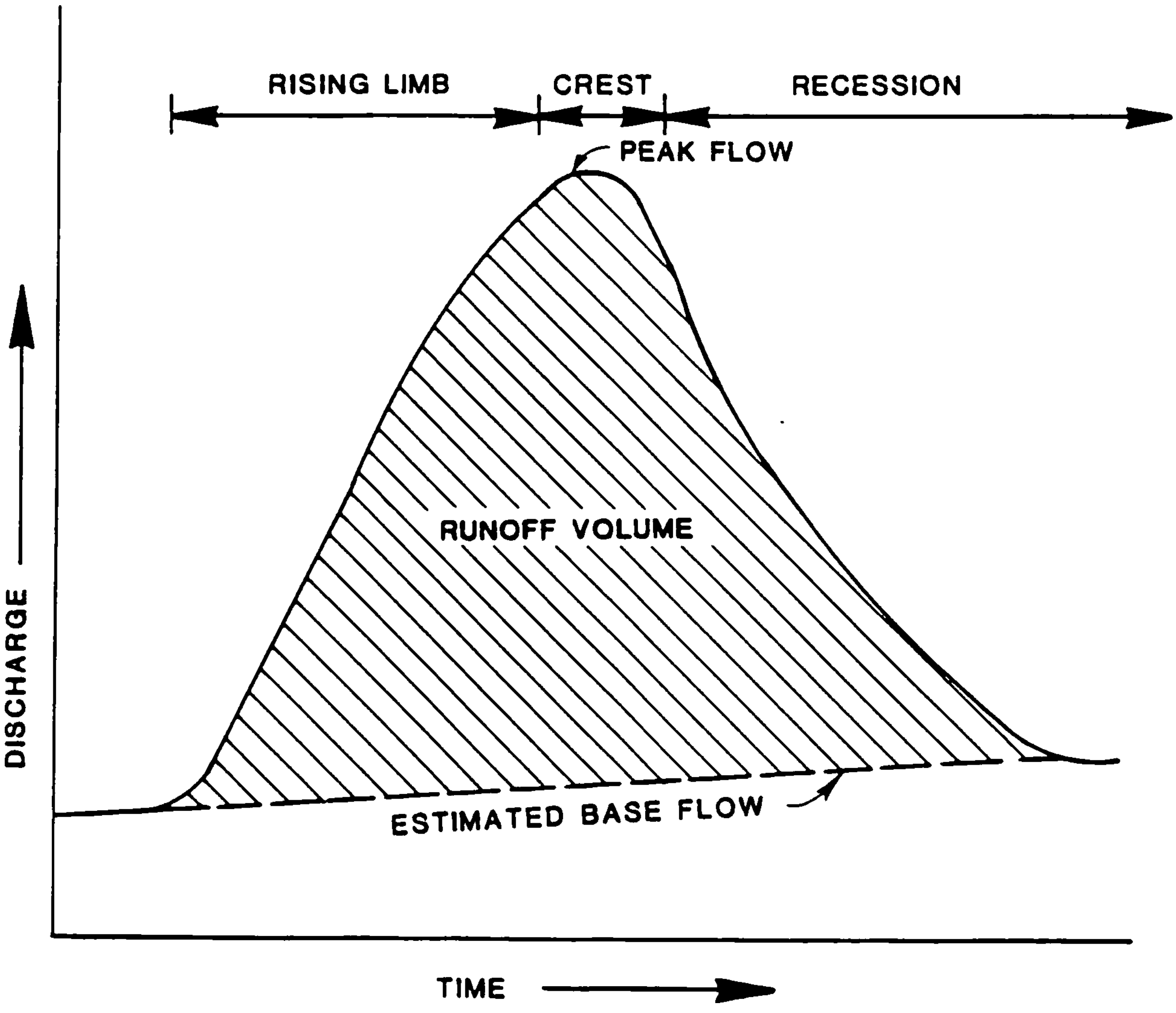
TABLE 5

SUMMARY OF ESTIMATED PEAK FLOWS FOR THE PMP RUNOFF EVENT IN THE GILT EDGE PROJECT HYDROLOGIC BASIN

Peak Flows (cfs) at Drainage Basin Outlets

Drainage Basin Outlet Design Point	PMP Event 6 Hour
1	1400
2	200
3	280

The peak flows, as modeled using the HEC-1 computer model, are greatest for the estimated PMP event. The soil was assumed to have an antecedent moisture condition II (AMC-II). Rain was applied at a rate of 19.6 inches for 6 hours.



GILT EDGE MINE PROJECT

EXAMPLE HYDROGRAPH
OF RUNOFF STREAMFLOW
FIGURE 5

Surface Water Monitoring Site Locations

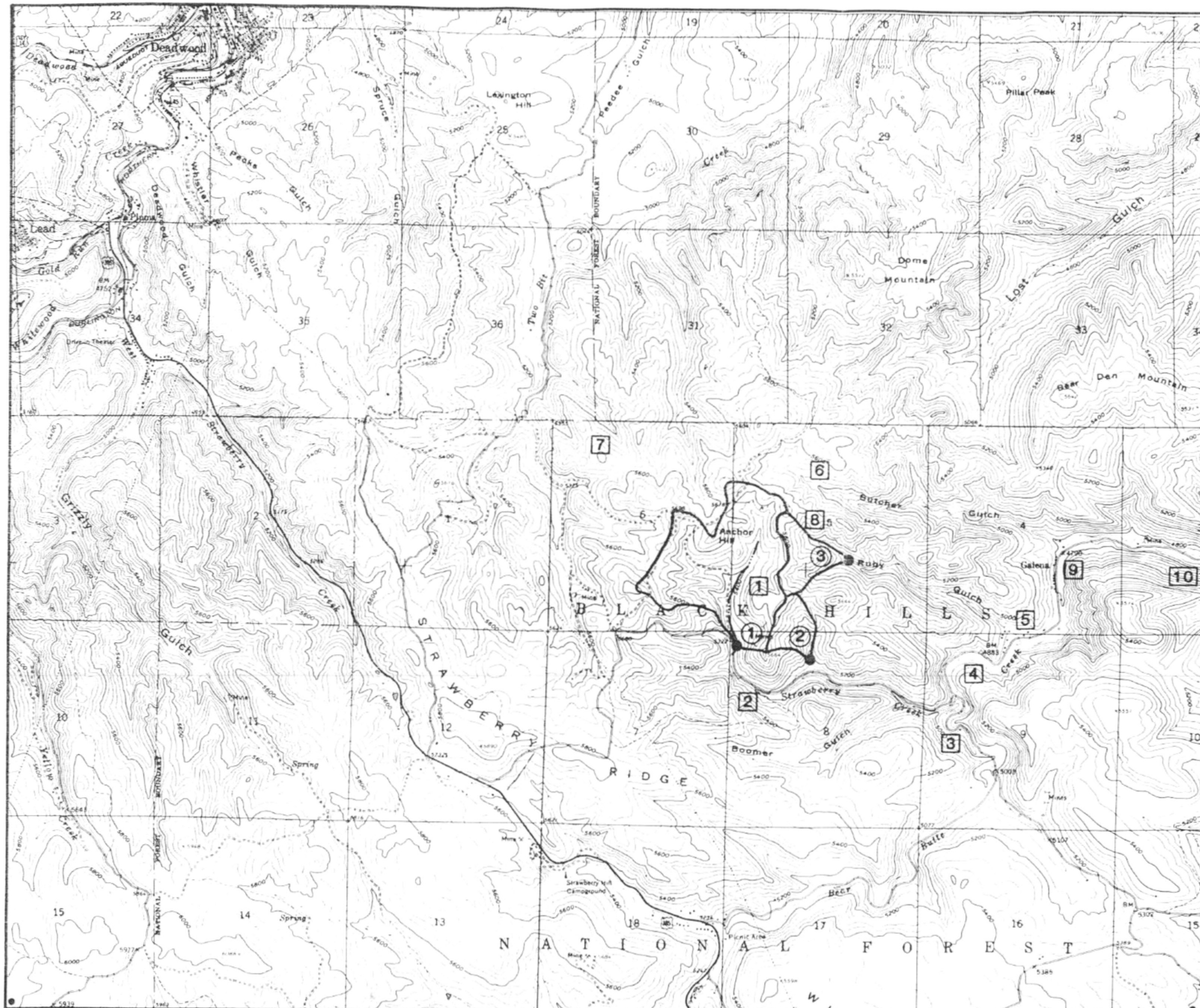
Surface water quality monitoring will be an integral part of the project. The primary objective of the water quality monitoring program is to establish environmental baseline data at the study area that can be used to document any potential degradation from existing land uses or any changes from proposed mining activity. Water quality monitoring sites are presented in Figure 6. Water quality monitoring will be continued during construction of the proposed project and continue throughout the project life and shutdown and abandonment phases. Sampling frequency will follow quarterly sample collection for the full range of parameters and at least one low flow and high flow sampling collection.

SUMMARY

The results of the surface water hydrology analysis for the Gilt Edge Project study area indicate that the PMP event runoff generates an extremely large peak flow for the size of the drainage basin (0.39 square miles). The entire study area is estimated to produce a maximum of 1,400 cfs at peak runoff during the PMP event.

For the purpose of designing for stormwater detention generated from the leach pad and plant facilities, the PMP event will be used. When designing for road culverts and all other drainage facilities, the general storm and thunderstorm events will be evaluated to determine design peak flows for sizing facilities. It is not feasible to size culverts, bridges, and stream channels for a 1,400 cfs capacity to accommodate drainage for an area of 0.39 square miles.

PMP events are normally only used when designing dams. In such a situation failure could cause loss of life. This is not the case with the downstream drainage area of the Gilt Edge mine project. Therefore, only the leach pad and plant areas will be designed to handle the PMP event.



0 2000 4000

scale feet

CONTOUR INTERVAL - 80 FEET

LEGEND

① SUBBASIN NUMBER

● DESIGN POINT

—— DRAINAGE BASIN BOUNDARY

-·-·- STRAWBERRY CREEK HEADWATERS

[3] WATER QUALITY MONITORING SITE

GILT EDGE MINE PROJECT

SURFACE WATER QUALITY MONITORING SITE LOCATIONS

FIGURE 6